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F-106 SCHEDULED MAINTENANCE IMPROVEMENT SUMMARY.(U)
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GENERAL DYNAMICS
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F-106 SCHEDULED MAINTENANCE IMPROVEMENT SUMMARY

Several studies have been conducted by the Convair Aerospace Division of General Dynamics, under sponsorship of the San Antonio Air Materiel Area, to develop methods for reducing F-106 maintenance costs and improving aircraft effectiveness. Analysis of the IRAN (Inspect and Repair as Necessary – depot-level maintenance) interval length led to a recommended 50% increase in the interval between IRANs – from 24 months to 36 months, with extensions to 48 months planned. An implementation plan was also developed to enable the F-106 fleet to be phased into the new IRAN interval without disruption of depot manloading and work flow. The IRAN study, documented in Convair report GDCA-AHD71-001, results in an annual savings of approximately $2.4 million for the F-106 fleet. The F-106 IRAN interval study methodology developed is currently being used to determine increased IRAN intervals for other USAF aircraft.

The IRAN study was followed by a study of base-level scheduled maintenance, which in turn is being followed by an analysis of F-106 NORS. An additional study, covering F-106 unscheduled maintenance, should be performed since unscheduled maintenance accounts for approximately 70% of the total base-level maintenance activity.

SCHEDULED MAINTENANCE STUDY

It has been generally believed that the F-106 weapon system is over-inspected and that significant savings in both scheduled and unscheduled maintenance manhours can be made through improvements in the scheduled maintenance program. This belief is borne out by the results of the F-106 Improved Scheduled Maintenance Study. This study was designed to streamline and improve the F-106 scheduled maintenance program through statistical analyses of historical maintenance data.

PROGRAM OBJECTIVES

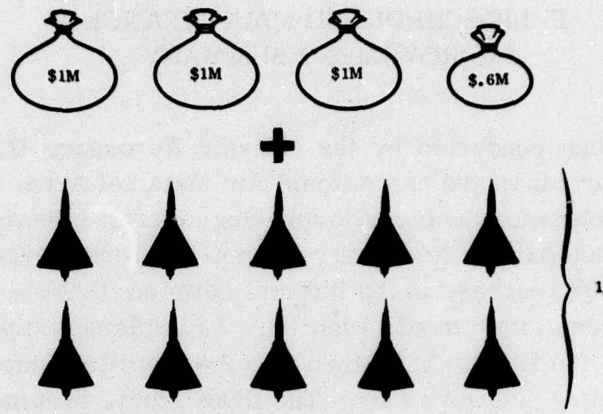
Program objectives were twofold. The primary objective was to provide an improved scheduled maintenance program for the F-106 that will reduce weapon system operating costs without adversely affecting aircraft safety and reliability.

The second objective was to provide the methodology used to perform the F-106 study in a format suitable for usage on other Air Force aircraft.

Convair successfully accomplished both of these objectives.

TOTAL PROGRAM SAVINGS

Expected results of incorporating the recommended changes to the F-106 scheduled maintenance program are:



In addition to the annual saving of $3.6 million indicated, there will be an increase in weapon system effectiveness, which is equivalent to adding 10 additional aircraft or half a squadron to the current fleet.

CURRENT SCHEDULED MAINTENANCE

The current scheduled maintenance program, intervals and man times in terms of man-hours per aircraft per year are shown below.

Inspection	Interval	Time (MH/Aircraft/Yr)
Preflight	Daily	426
Basic Postflight	After Flight	493
Hourly Postflight	50 FH	353
Periodic - Aircraft	300 FH	392
- Engine	300 FH	
- Corrosion	300 FH	
2nd Periodic	600 FH	
MA-1	45 Days	165
	90 Days	
Specials		1573
Scheduled Maintenance Manhours/Aircraft/Year		= 3402
Total Organizational Level Maintenance		= 5140

Interval data was extracted from 1F-106A-6, while the manhour data was obtained from the AFM66-1 data file.

Of the 5140 manhours per aircraft per year for direct organizational maintenance of the F-106, about 3400 are expended on scheduled maintenance. Since scheduled maintenance accounts for only about 30% of the total maintenance dollars (including intermediate-level maintenance), however, only a small portion of the total problem has been examined. Obviously, unscheduled maintenance, representing 70% of the total problem, should be the subject of a similar study.

SCHEDULED MAINTENANCE STUDY

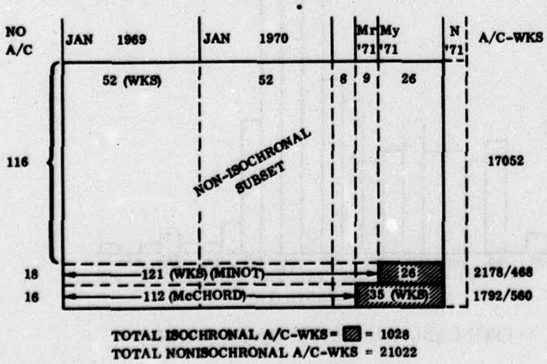
The scheduled maintenance study program was conducted in three phases. Phase I, Data Collection, included visits to three ADC squadrons, screening of historical maintenance data, and generation of an F-106 maintenance data bank.

During Phase II, Analysis, a set of six statistical analysis computer programs, an analytical effectiveness program, and a cost model were developed. These models, using the data bank generated during Phase I, were utilized in the analysis of the scheduled maintenance program.

The results of Phase II were used in Phase III to develop a new scheduled maintenance program. In effect, Convair wrote a new -6 handbook. A transition strategy for placing all aircraft on the new scheduled maintenance program from the current program was developed. A computer program user's manual was then compiled to describe the programs and their operation, and to indicate how to analyze the data generated.

PHASE I

The data bank generated during Phase I covers 150 F-106 aircraft. The geographic distribution of aircraft, and the ratios of F-106A versus F-106B aircraft and "Round Eye" versus Vertical Instrument aircraft, are identical to the distributions for the total fleet. Thus, the data for the 150 aircraft sample is truly representative of the data generated by the total fleet.



Data Bank Coverage

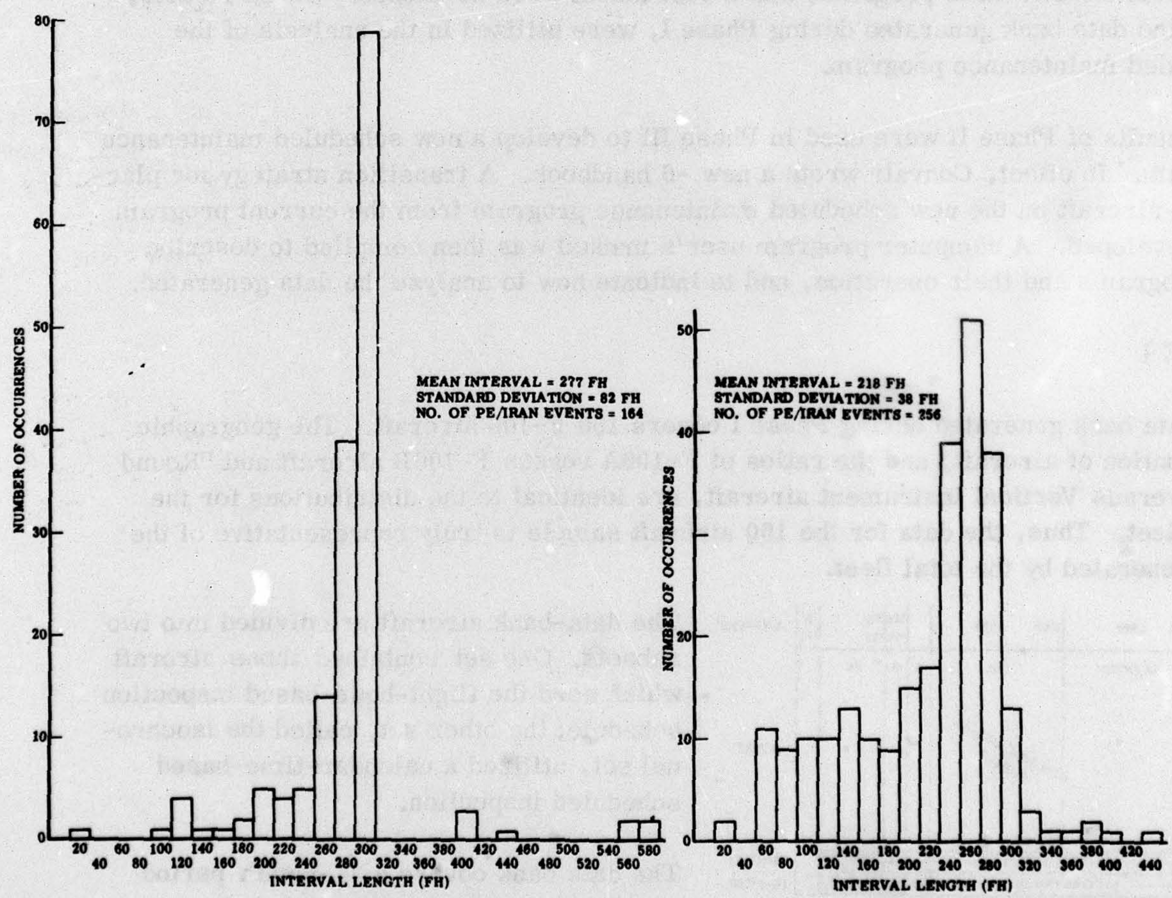
The data-bank aircraft are divided into two subsets. One set contained those aircraft which used the flight-hour-based inspection schedule; the other set, called the isochronal set, utilized a calendar-time-based scheduled inspection.

The data bank covers a 34-month period starting in January 1969 and ending in October 1971. During this period, the data-bank aircraft generated 108,500 flying hours.

Contents of the data bank include AFM66-1 data, AFM65-110 data, Accident, Incident and EUMR data, and IRAN input dates plus data furnished by the operating squadrons and by Convair Aerospace technical representatives. The data comprises about 600,000 individual records. These records can be sorted by tail number, date, work unit codes, type of maintenance, etc.

Numerous problem areas were discovered during assembly of the data bank, especially with the AFM66-1 data. These problem areas included recording erroneous unit-of-work quantities, incorrect numbers of preflight and postflight inspections, and inaccurate recording of periodic inspections.

The accompanying chart indicates one of the major data-recording problems encountered. The right-hand bar graph, derived directly from AFM66-1 data, shows that the mean interval between periodic inspections is 218 flying hours per aircraft. If this were true, the obvious recommendation would be to improve the scheduling of aircraft into periodic inspection to more nearly approach the current limit of 300 flying hours.



FROM SQUADRON RECORDS

FROM 150-AIRCRAFT DATA BANK

PE/IRAN Intervals Distribution

To check this result, data direct from the squadron records was requested. The results are shown in the left-hand bar. The mean interval jumped to 277 flying hours, which is an increase of 27%. This serious discrepancy between squadron records and 66-1 data is directly attributable to errors in the management information system.

Since management cannot operate effectively when the information with which they must work is inaccurate, changes in the data collection methods of AFM66-1 were recommended. Specifically, it was recommended that preprinted Form 349s be prepared so that the only data items a technician must write down are his name, identifier, and time spent on the job. He would then merely circle the appropriate codes (How Mal codes, Action Taken codes, etc.) on the preprinted form. More detailed information on this and other recommendations is contained in the F-106 Scheduled Maintenance Study Final Report, GDCA-AHD72-005.

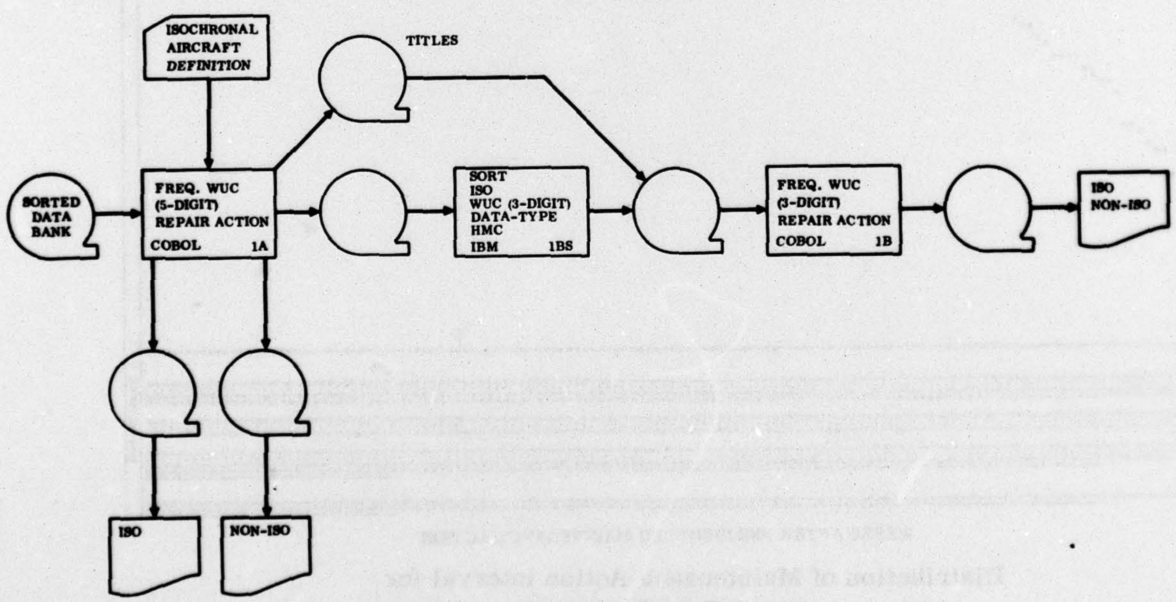
PHASE II

Six sets of statistical analysis programs were developed during the study.

Task I	Maintenance Action and Inspection Frequency Analysis
Task II	Manhour and NOR Time Analysis
Task III	Maintenance Action and Inspection Interval Analysis
Task IV	Effect of Time After Inspection Analysis
Task V	WUC Removal Analysis
Task VI	Aircraft Inspection Histories

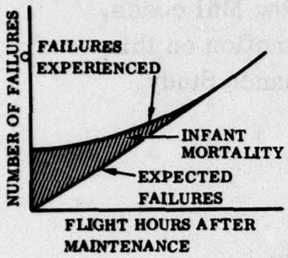
The most useful analyses were those represented by Tasks I, III and VI.

Task I identified the inspection items where malfunctions were never discovered, and also identified items that were not currently inspected, but should be inspected because of their high rate of failure.

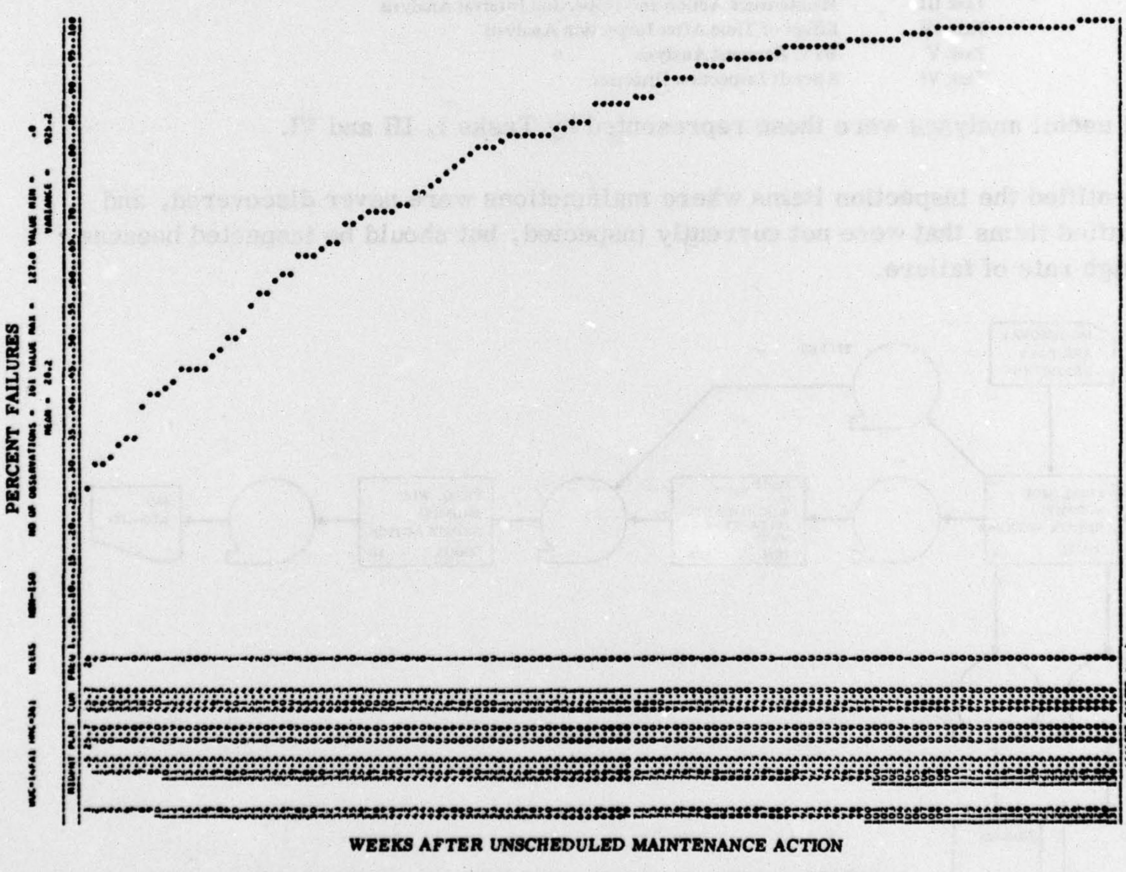


Frequency (Task I) Block Diagram

The most interesting data was found during Task III. As mentioned previously, scheduled maintenance represents about 30% of the total maintenance charged to the aircraft. Task III identified the number of repeat writeups or "infant mortality" for each WUC. "Infant mortality" is described as a repeat writeup on the same WUC on the same aircraft within four flying hours of the previous writeup. This represents a significant portion of unscheduled maintenance (the 70 % of the problem which has not been studied). Almost every WUC indicated a significant repeat writeup problem. In numerous cases, these "infant mortality" problems resulted in 30% to 50% of all the failures charged to that item. The magnitude of this problem cannot be overemphasized, since it represents a considerable portion of unscheduled maintenance and is usually avoidable. Causes for the maintenance errors leading to high "infant mortality" are both hardware (design or reliability) and human (motivation, skills, technical data). It is strongly recommended that a study be conducted to identify the specific causes of "infant mortality" and to determine solutions to rectify this situation. The following actual computer printout obtained during the study illustrates a 26% "infant mortality" for a flight control valve.

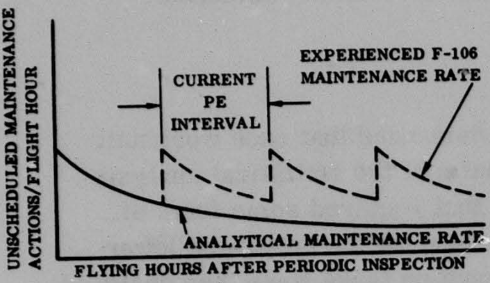


Maintenance Errors



Distribution of Maintenance Action Interval for 14FA1 – Leaking, Internal and External

Another interesting discovery is illustrated in the following figure which indicates that, analytically, the number of unscheduled maintenance actions per unit time continues to decrease as the time after inspection increases. That is, once a system has been disturbed by scheduled inspection it generates higher maintenance rates until it gets enough operating time to return to a steady-state failure rate. Unfortunately, the F-106 inspection intervals are so short that almost none of the systems will reach the steady-state failure rate.

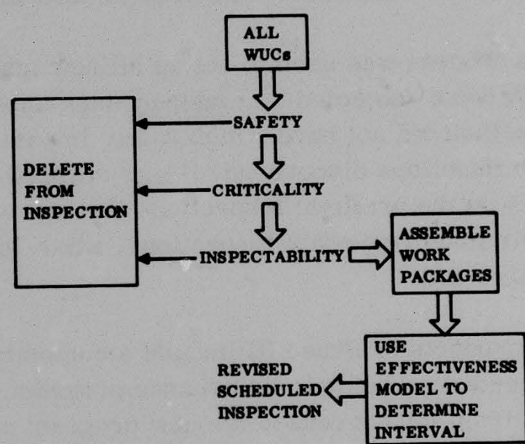


Effect of Scheduled Maintenance on Unscheduled Maintenance

Results of the Task VI analysis identified the periodic interval problem previously discussed and led to recommendations for improvements in scheduling to provide more aircraft flying hours between scheduled inspections.

MAINTENANCE PROGRAM DEFINITION

This sketch represents the process used to determine which WUCs would be inspected. Each WUC entered the flow at the top and was subjected to three sets of screens. The first screen identified the safety implications associated with each item. If the item had no adverse effects on safety and had never caused aborts or loss of mission, it was immediately dropped from further consideration for scheduled inspection.



Maintenance Program Analysis

The second screen, criticality, identified mission-critical items and items causing excessive abort rates. All WUCs not in these categories were deleted from inspection. The third screen, inspectability, identified the items capable of being inspected. Items that cannot be inspected economically were dropped.

WUCs not filtered out by any of the screens were those codes requiring inspection.

The remainder of the chart shows the determination of the preliminary inspection packages and use of the effectiveness model to determine inspection intervals.

EFFECTIVENESS MODEL

The effectiveness model is a computerized probabilistic model of an aircraft undergoing one cycle of a maintenance program. The model determines the aircraft effectiveness (in terms of availability and dependability), the aircraft NOR rate, and the manhours required to maintain the vehicle.

The model includes the effects of scheduled inspections with the ability to vary both inspection content and interval. Limitations on inspection interval length, due to hardware design, were included as model inputs. Special inspection interval and content, unscheduled maintenance, and aircraft utilization effects were also considered.

PHASE III

Defining a new F-106 scheduled maintenance program demanded that each work unit code (WUC) be considered on an individual basis. Results of the statistical analysis programs were analyzed to identify the specific WUCs that required some form of scheduled inspection. Failure data was then used to determine the upper and lower time limits for inspection of each of these WUCs. Inspection tasks were then designed to provide adequate condition verification of each WUC requiring inspection. These tasks were grouped into packages according to the time limits placed on each WUC, and the effectiveness model was used to determine optimum intervals for each inspection.

This process was used to set up all new inspections (except preflight and postflight), which were subjected to a task-by-task analysis using the statistical analysis data. If the task did not have a high safety impact and had not resulted in a significant number of malfunctions discovered, it was dropped from the preflight or postflight inspection. Items on the preflight inspections that were also inspected after flight were scrutinized to eliminate redundant inspections, where possible, consistent with safe operation of the aircraft.

The products of Phase III include a completely new "-6" handbook describing the recommended scheduled maintenance program. The optimum method for transitioning the fleet from the current to the new program calls for a nine-month test program involving three squadrons. Each aircraft in the test squadrons would be placed on the new scheduled maintenance program subsequent to its next hourly or periodic inspection. When the test program is successfully completed, all other squadrons would be similarly transitioned.

A computer user's manual to explain the usage and analysis of all programs developed during this study has been delivered to SAAMA, along with the F-106 data bank described previously.

The user's manual is report No. GDCA-AHD72-006; the final report covering this study is Convair Report No. GDCA-AHD72-005.

The effectiveness model was exercised, using parameters from the current and recommended scheduled maintenance programs. Comparison of results indicates that the recommended program will increase effectiveness from 0.72 to 0.76 and decrease NOR rate from 0.23 to 0.19 — equivalent to adding 10 aircraft to the existing fleet. There will also be a decrease of seven manhours per flight hour (1540 manhours per aircraft per year), resulting in an annual savings of $3.6 million.

RECOMMENDED SCHEDULED MAINTENANCE PROGRAM

This table shows the recommended scheduled maintenance program. Inspection intervals from the current program are shown for comparison. The new Preflight and Basic Postflight occur at the same intervals as the existing inspections, but the content of the inspections has been reduced.

Comparison of Current and Recommended Scheduled Maintenance Approaches

Inspection: Current	Inspection: Recommended	Interval: Current	Interval: Recommended*	Time (MH/Aircraft/Yr): Current	Time (MH/Aircraft/Yr): Recommended
Preflight		Daily		426	253
Basic Postflight		After Flight		493	382
Hourly Postflight	Minor	50 FH	100 FH	353	179
Periodic 2nd Periodic	Major	300 FH 600 FH	400 FH	392	208
MA-1		45/90 Days	100 FH	165	‡
—	Service/Lube	—	200 FH	—	‡
Engine		300 FH		†	73
Special		Variable		1573	979
			Total	3402	2074
			Minus Recommended	2074	
			Savings	1328	MH/Aircraft/Year (39%)

* 10% overrun allowable
‡ Included in major and minor inspections
† 73 mh included in periodic inspections

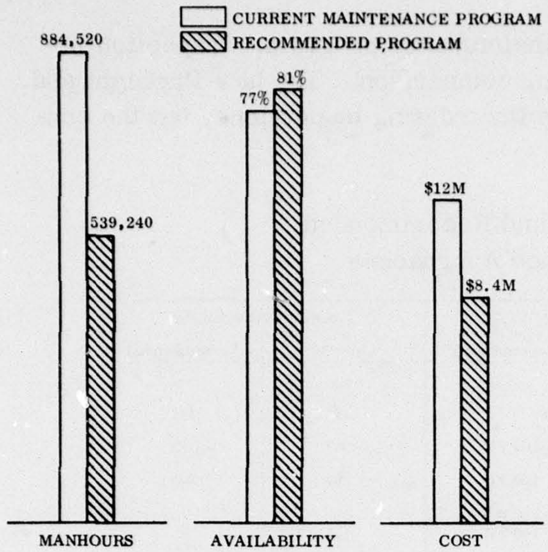
The Minor inspection (which replaces the Hourly Postflight) occurs at 100-flying-hour intervals, while the Major inspection (which replaces the Periodic) occurs at 400-flight-hour intervals. Since engine inspections were not included in the study, engine time could not be extended and a 300-hour engine inspection was required. This inspection package includes the tasks for all airframe items requiring engine removal for inspection. Thus, the engine inspections are no longer tied to airframe inspections.

A 200-flight-hour Service and Lube task was added. Only minor changes were made to Special inspections.

Finally, it is recommended that the current (45-day) MA-1 minor inspection be dropped and that the current 90-day inspection be performed every 100 flying hours. This provides a reduction in ground operating hours for the system. The high rate of unscheduled MA-1 maintenance plus frequent scheduled inspections cause an excessive amount of ground run time, which further contributes to the system reliability problem.

All recommended flying hour intervals are allowed a 10% overrun for scheduling flexibility.

The recommended program results in manhour savings of about 40%. Actual manhour expenditures with the recommended program should be 2074 manhours per aircraft per year, compared with the 3402 manhours per aircraft per year under the current program.



TOTAL PROGRAM SAVINGS FOR F-106 FLEET

In terms of dollars, the current scheduled maintenance program costs $12,028,000 annually while providing an availability of about 77%. The effectiveness model predicts that the recommended program will cost $8,417,000 and provide an availability of 81%. Thus, there is a $3.6 million annual saving for the F-106 fleet, and the increase in availability effectively adds 10 aircraft or one-half of a squadron if the recommended program is adopted.

The study which delineates the new scheduled inspections has cost less than 10% of the estimated savings for one year of the new program.

RECOMMENDATIONS

The following recommendations are made as a result of the knowledge gained during the scheduled maintenance study.

- Perform Test Program with Convair Monitor and Analysis
- Adopt New Scheduled Maintenance Program
- Utilize Methodology for Other USAF Aircraft
- Utilize Methodology for Aircraft Engines
- Utilize Additional Data Collection Effort for Future Studies
- Investigate Items with Multiple Repeat Maintenance Actions

A test program should be performed, utilizing three squadrons, for a nine-month period. Convair Aerospace should monitor the test and analyze the resulting data. After successful completion of the test program, the new scheduled maintenance program should be implemented for the remainder of the fleet. The resulting savings are substantial, but they are only the beginning.

The methodology developed for this study provides significant new insights into the interactions between scheduled and unscheduled maintenance. This method is highly effective in reducing overall operating costs and should be applied to studies of the scheduled maintenance programs for all USAF aircraft and engines. Recognition of the data collection problems associated with the AFM66-1 system leads to the recommendation that future studies of this type place greater emphasis on contacts with operating units and use of additional data sources to provide the best study results.

Identification of the highly significant repeat writeup problem on the F-106 leads to the recommendation for a study of this problem. Remember, this is the unscheduled maintenance problem that has not been investigated. If 30% of the problem (scheduled maintenance) yields potential annual savings of $3.6 million, what will the 70% yield?

GENERAL DYNAMICS

Convair Aerospace Division